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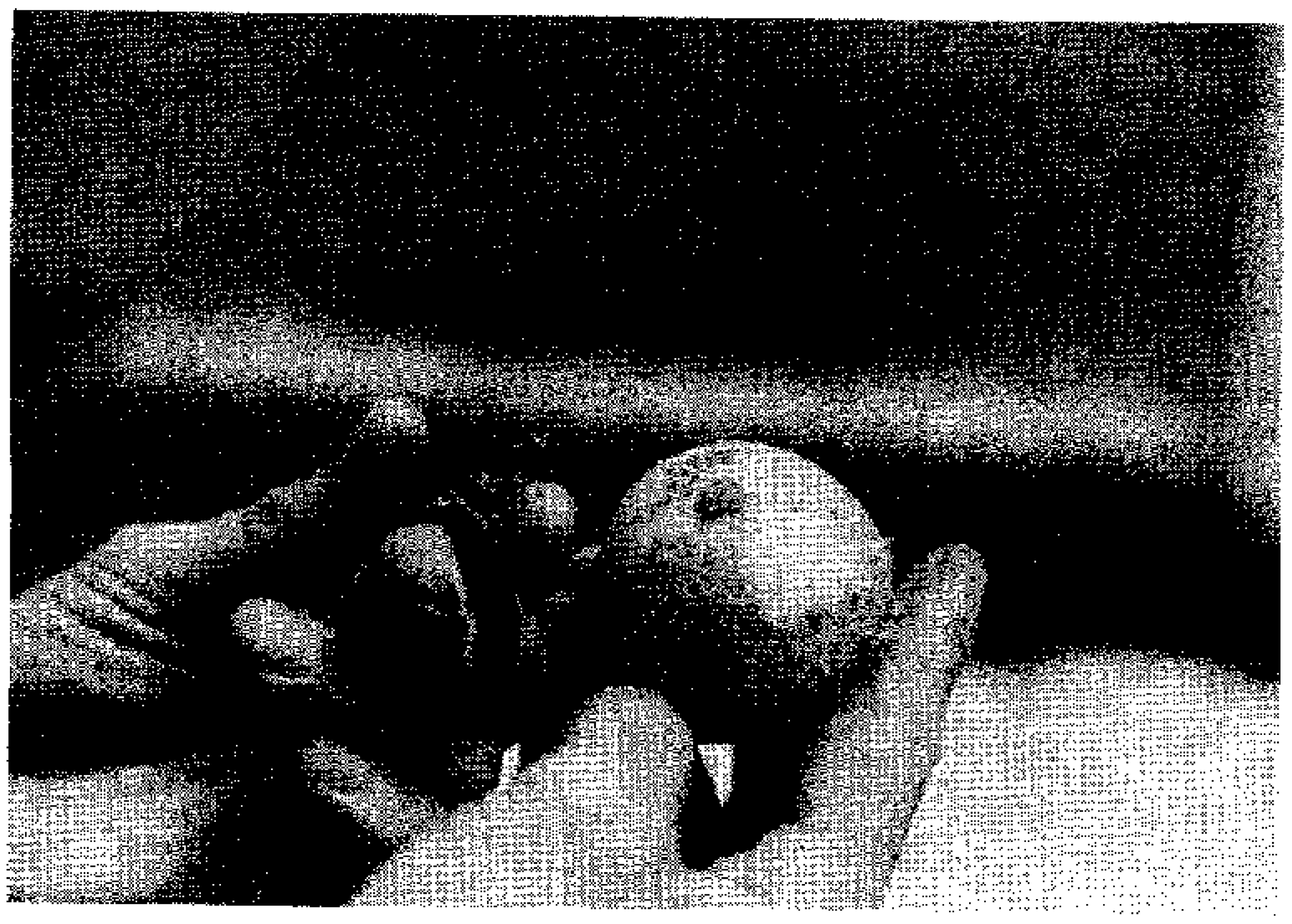

**Figure 1.** Newly hatched sea turtle and an unhatched egg. Photo courtesy of Texas Sea Grant College Program.

can be carefully controlled, it is possible to manipulate the sex of the turtles produced.

Various predators will dig up turtle eggs. Known predators of green sea turtle eggs include crabs, insects, reptiles, mammals, and birds. At one time, it was common practice for people to dig up turtle nests and harass the females on the beaches, but with the development of a strong conservation ethic and, more recently, active attempts to protect sea turtles and their eggs on the nesting beaches, that practice is now rare. More common is a female sea turtle disrupting an existing nest by digging a new nest pit in the same location.

All of the eggs that hatch in a nest do so over a brief time span. Hatchlings climb to the surface in a synchronous fashion over a period of days, using one another as "stepping stones" to move upward, in a virtual ball of baby turtles. Once they reach the surface, they scamper down the beach to the ocean (Fig. 2). Predators can take a heavy toll when the hatchlings are on the beach, but the vulnerability of the turtles to predation certainly does not end when they enter the water. Unable to dive until they have grown significantly, the young turtles are vulnerable to attacks from both above and below. Hatchlings have reportedly been preyed upon by crabs, fish, reptiles, mammals, and birds. Juveniles and adults have fewer predators, but there have been reports of attacks by a few species of fish, including sharks; a species of crocodile; and at least one type of marine mammal.

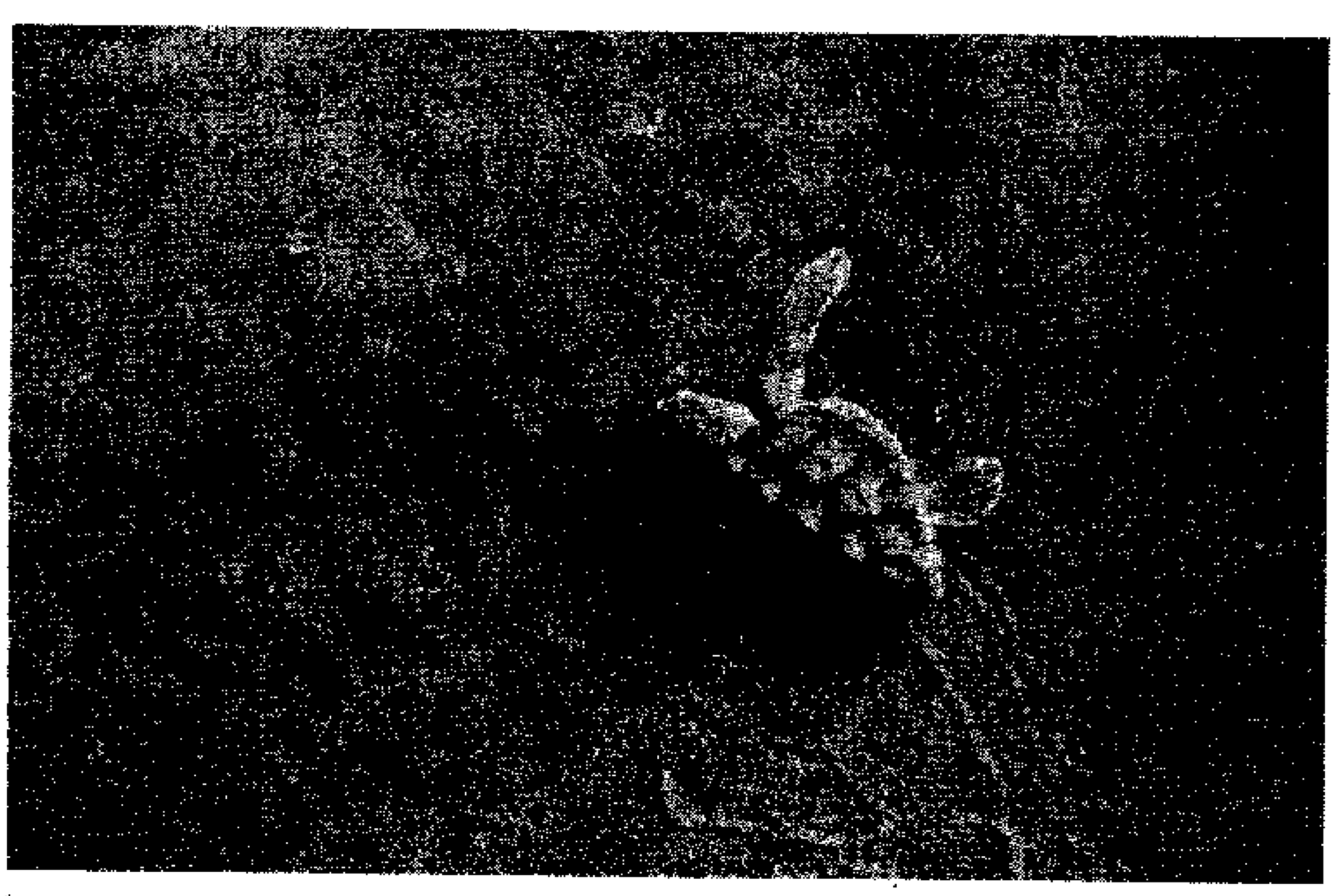

**Figure 2.** Hatchling heading for the water. Photo courtesy of Texas Sea Grant College Program.

Most sea turtles are carnivores, although the green sea turtle is an herbivore that consumes sea grasses and algae of many varieties. Being a vegetarian, the green turtle does not have a strong flavor and for that reason became the most desirable species for human consumption. When the Americas were being colonized and European explorers were charting the oceans of the world from sailing ships, it was common practice to capture green sea turtles and strap them, upside down, to the decks of the ships. The turtles would live for long periods and provide fresh meat to sailors, who would otherwise have to exist on salted meat and fish.

Turtles tend to be true to their nesting beaches. Females will faithfully nest on the same stretch of beach where they were hatched. However, many beaches that once were used by nesting turtles have been abandoned, because human activity has either prevented access or scared the turtles away. Overfishing and destruction of nests by humans and other predators have also contributed to the demise of some nesting beaches. Recovery efforts often require moving eggs from the beach on which they were laid to another beach, where final incubation occurs, often in a hatchery situation. The hatchlings will, through a process known as imprinting, have a "memory" of the beach implanted in their brains that will cause them to return to the beach where they entered the ocean as hatchlings, not where they were deposited as eggs. Thus, in theory, new nesting beaches can be established and abandoned ones put back into use.

## MARICULTURE

Culture of turtles has been for the purpose of assisting in the recovery of threatened and endangered species and for food production. Early recovery efforts involved collection of eggs laid in nature, incubation of those eggs in hatcheries, and immediate release of hatchlings into the ocean. Because of high mortality rates, however, an additional step, called head-starting, is sometimes employed. This technique involves maintaining the young turtles in captivity for several months, until they are able to dive and have attained sufficient sizes and swimming speeds to allow them to avoid many of the common predators (see the entry "Sea turtle culture: kemp's ridley and loggerhead turtles" for more detail). In addition to head-starting Kemp's ridleys and loggerheads, similar activities have been undertaken with green and hawksbill turtles (1,2).

Mariculture, Ltd. was the first sea turtle farm. Established in 1968 on Grand Cayman Island in the British West Indies, it was acquired by Cayman Turtle Farm, Ltd., in 1975 and by the Government of the Cayman Islands in 1983 (1,2). It remains in business and is the largest and longest running sea turtle mariculture operation in the world. A great deal has been learned about green sea turtle biology and culture over the three decades that the farm has been operating. In addition, the farm has developed a captive breeding program with Kemp's ridley turtles.

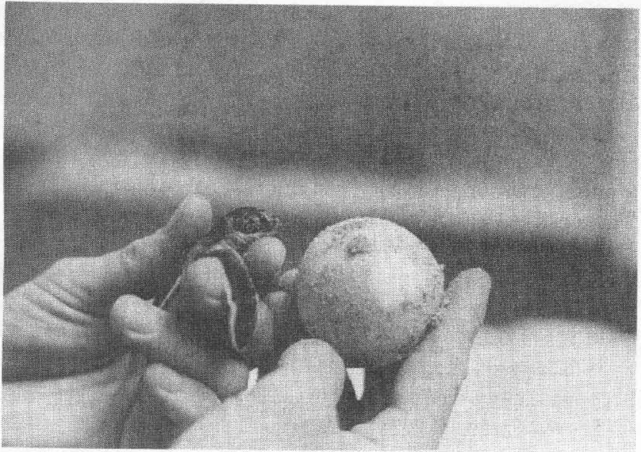

**Figure 1.** Newly hatched sea turtle and an unhatched egg. Photo courtesy of Texas Sea Grant College Program.

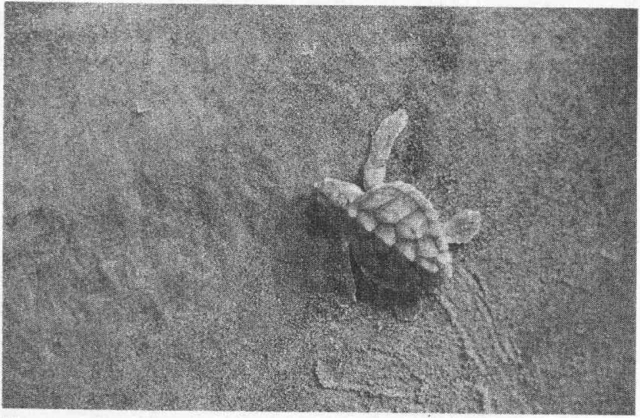

**Figure 2.** Hatchling heading for the water. Photo courtesy of Texas Sea Grant College Program.

Taking its initial stock of green turtle eggs and adults from the wild, the Cayman Island farm was able to develop a captive breeding program, though in the 1970s it continued to obtain eggs from nesting beaches to supplement its production. In the 1970s, annual production ranged from 12,000 to 15,000 turtles. Virtually every part of the turtles produced were marketed. Included were the meat, oil, fatty tissue (known as calipee), leather from the skin, and shell. Yet, the farm was not a profitable operation. The situation become worse when changes in CITES regulations and the listing of green sea turtles under the Endangered Species Act in the United States, banned the importation of turtle products and their transshipment through Miami.

Once the Government of the Cayman Islands took over the farm in 1983, it was developed into a tourist attraction as well as a production operation. The farm is located on 6.4 ha (16 acres) of land. It features, in addition to the tourist center, a breeding pond, a hatchery, rearing tanks, research laboratories, an administration building, and a processing plant.

By 1988, the farm was showing a profit, largely based on fees paid by tourists. It was also moving closer to being able to export some of its products under CITES criteria, which included a provision under which second-generation captively produced turtles were exempt from the distribution ban.

In 1973, five years after the farm was established, adult turtles that had been held in captivity since the farm was established finally produced viable eggs. The first generation of captively produced females (hatched in 1973 and 1974) reached maturity and laid eggs first in 1989. It is the offspring of the 1989 adults that are the second-generation turtles that meet the CITES criteria. By 1992, the captive breeding population on the farm had reached a total of 280 turtles, with a ratio of three females for each male being maintained.

The main emphasis of the farm in the past several years has been on research and head-starting, with only limited production for sale. Tourism and local meat sales are primary income sources. About 4,000 turtles are marketed annually at 3.5 years of age, when they weigh about 24 kg (48 lb). The farm's head-start program began in 1980. Tourists and residents become involved in the head-start program by paying a fee for the privilege of releasing the turtles. By 1992, more than 22,000 head started turtles had been released (5).

Sea turtles require clean water, or else they become susceptible to a variety of diseases, including skin lesions. At high densities, daily tank cleaning is required unless flow-through water is used in the culture system.

Unlike finfish and invertebrate culture species, each species of sea turtle seems to have its own personality. Green sea turtles are docile and do not mind being touched. Kemp's ridley and loggerhead turtles tend to be more aggressive than green turtles, but the public enjoys watching all sea turtle species when they are on display. While not as popular as marine mammals, sea turtles do have a large following among those who visit public aquaria and various tourist attractions that feature aquatic animals.

The major remaining Kemp's ridley sea turtle nesting beach in the world is at Rancho Nuevo, Mexico. A few green turtles and loggerheads also nest at Rancho Nuevo. Collaboration between U.S. and Mexican government agencies and scientists to protect Kemp's ridley turtles has been ongoing for several years. During the nesting season, people from both nations gather at Rancho Nuevo to count the number of ridley nests and in some cases gather eggs for incubation in corrals located elsewhere on the beach. Most of the turtles hatch naturally or are released at Rancho Nuevo, but some have been used to reestablish nesting beaches in the United States as well. As a result of these activities, aided in no small part by conservation efforts, the number of nesting females at Rancho Nuevo has increased considerably. Kemp's ridley head-starting efforts also seem to be paying off, as at least a few tagged individuals known to have been head-started have been observed on nesting beaches at Padre Island and Mustang Island in south Texas.

Many sea turtle populations continue to be threatened or endangered around the world, but their plight is not quite so perilous as it was only a few years ago.

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See also SEA TURTLE CULTURE: KEMP'S RIDLEY AND LOGGERHEAD TURTLES.

# SEA TURTLE CULTURE: KEMP'S RIDLEY AND LOGGERHEAD TURTLES

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## OUTLINE

On a worldwide basis, sea turtle aquaculture is conducted for commerce and conservation (1). The U.S. Departments of Commerce (DOC) and the Interior (DOI) are responsible for protecting sea turtles under the Endangered Species Act, thus limiting sea turtle aquaculture in the United States to research and conservation. In 1977, the National Marine Fisheries Service (NMFS) laboratory in Galveston, TX, initiated sea turtle aquaculture research related to conservation, first with loggerhead turtles (*Caretta caretta*), a threatened species, and then with endangered Kemp's ridley turtles (*Lepidochelys kempi*). This research requires scientific permits and threatened- and endangered-species permits from the Texas Parks and Wildlife Department (TPWD), the Florida Department of Environmental Protection (FDEP), the U.S. Fish and Wildlife Service (FWS), and Mexico. When eggs, hatchlings, or larger turtles are received from other countries, Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) export and import permits also are required.

## RATIONALE

At a meeting in Austin, TX, in January 1977, representatives of Mexico's Departamento de Pesca, the U.S. Department of the Interior [specifically, the National Park Service (NPS) and FWS], the U.S. Department of Commerce (specifically, NMFS), and TPWD established a Kemp's ridley recovery program (2–5). At that time, the annual number of Kemp's ridley nesters was less than 800 and declining at the species' primary nesting site near Rancho Nuevo, Tamaulipas, Mexico (6) (see Fig. 1). Program objectives were to increase protection of nesters, eggs, and hatchlings at Rancho Nuevo; reduce incidental capture of sea turtles in shrimp trawls; and encourage research leading to improved management and population recovery. Prior to the interagency meeting, NPS and FWS regional representatives had been discussing a potential feasibility study (later called the "Kemp's ridley headstart experiment") aimed at establishing a nesting colony of Kemp's ridleys at Padre Island National Seashore (PINS), near Corpus Christi, TX (3–5). The experiment involved collecting and incubating eggs, imprinting hatchlings, and then captive rearing, tagging, and releasing the turtles into the Gulf of Mexico within their first year of life. It protected them from predators and other causes of mortality associated with those early life stages. Mexican agencies, FWS contractors (initially, the Florida Audubon Society, Maitland, FL; then Gladys Porter Zoo, Brownsville, TX) and volunteers carried out the Rancho Nuevo operations (6,7); NPS conducted incubation and imprinting at PINS (5,8); and the NMFS Galveston Laboratory captive

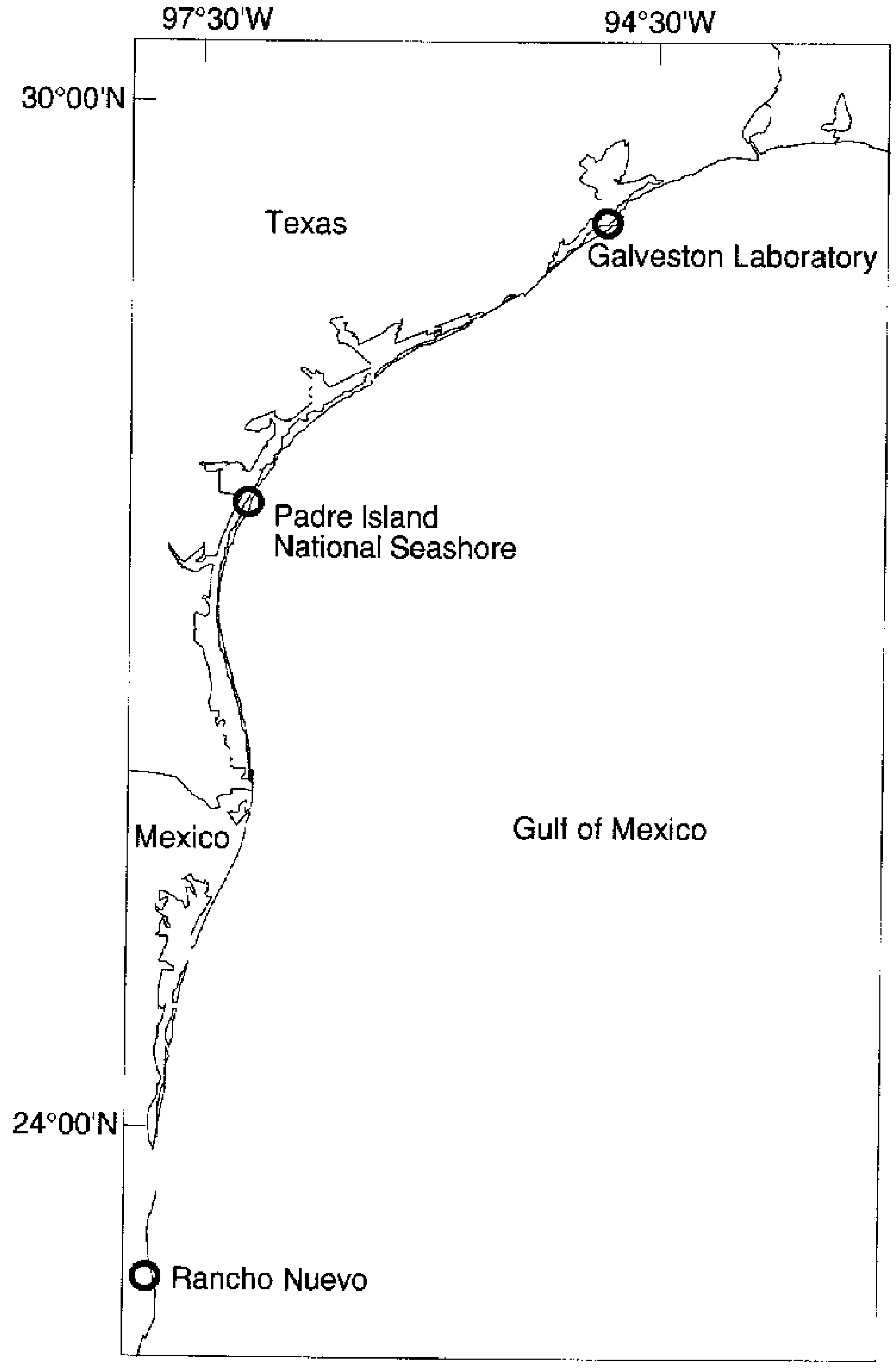


**Figure 1.** Locations of the Galveston Laboratory, Padre Island National Seashore, and Rancho Nuevo.

reared, tagged, and released the turtles into the Gulf of Mexico (9–11).

Regulations requiring turtle excluder devices (TEDs) in shrimp trawls were implemented during the late 1980s and early 1990s (12). The regulations led to the development of procedures to test TEDs before they were certified for use in shrimp fisheries. Certification required that a sample of sea turtles, passed one at a time through a TED installed in a shrimp trawl, rapidly escaped through the TED. The Galveston Laboratory was and continues to be the source of turtles used in TED certification procedures. Both Kemp's ridleys and loggerheads have been used in TED certification procedures, but two-year-old loggerheads have become the standard.

In addition to their use in the headstart experiment and TED certification procedures sea turtles at the Galveston laboratory have been the subjects of research on physiology (reproductive, respiratory, metabolic, fitness, anesthetic, and submergence), chemical imprinting, tagging, sex determination, temperature–sex relationship, and diseases. The laboratory also attempts to rehabilitate sick and injured sea turtles obtained from the wild and then releases those that do not have incurable illnesses or debilitating handicaps.

## LIFE HISTORY PATTERN

Sea turtle species include leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), flatback (*Natator depressus*), loggerhead, olive ridley (*Lepidochelys olivacea*), Kemp's ridley, and hawksbill (*Eretmochelys imbricata*) (13). These species all have similar life history patterns (14), with the greatest part of the multidecade life span spent at sea, where capture, observation, and tracking are difficult and costly. In contrast, much has been learned through studies of sea turtles in captivity, at nesting sites, and by examining carcasses found stranded on barrier beaches. Specific life history characteristics of Kemp's ridley (15,16) and loggerhead (17,18) turtles have been described in detail.

Adult female sea turtles ascend beaches to nest during spring and summer, sometimes more than once during a nesting season, but not always each year (19,20). Females dig nests with their rear flippers, deposit clutches containing around 100 eggs each (ranging from tens to fewer than 250 eggs per clutch, and varying with species), and then cover the eggs with sand before returning to the water. The whole process takes about 0.8–2.5 hours, depending on the species. The eggs hatch after incubating 6–13 weeks, depending on the species and the temperature (20). Hatchlings emerge from the nest and crawl down the beach to the water. Recent studies suggest that a hatchling's biological compass is set during this crawl down the beach, providing a mechanism for possible magnetic navigation back to the nesting site after the turtle matures (21).

Eggs and young sea turtles are especially vulnerable to environmental factors, predation, and human activities (22–24). Eggs are eaten by crabs, small to medium-sized mammals, reptiles, birds, and humans, but they also sometimes succumb to inundation by high tides, heavy rain, or flood waters and invasions by insects, microbes, fungi, and plant roots. Hatchlings are exposed to avian, mammalian, and crustacean predators on their way to the water, where they are then faced with added threats from fish, molluscs, other marine animals, and sea birds. They swim out to sea, drifting with ocean currents and foraging for food near the surface for a year to more than a decade, depending on the species (24,25). Little is known about the whereabouts and habits of turtles at this young life stage, which precedes the larger immature and adult stages that are capable of benthic feeding. Turtles at the larger stages are vulnerable to both deliberate and incidental capture by various fishing gears and methods (12,23,24,26). Diet and feeding habits, from omnivory to carnivory, vary considerably among species (27).

Estimates of age at sexual maturity vary within species and range from one to five decades among species (24,28). Copulation takes place on migratory routes to nesting beaches, as well as near nesting beaches (20; David Owens, personal communication, February 1998). Males have large, curved claws on their foreflippers; their plastrons soften and depress during the mating season; and they have long, thick tails and large, curved penises. All of these factors aid the males in grasping females during copulation, which can last for hours (20,28). Females can store sperm to fertilize multiple clutches of eggs during a nesting season (20,29).

## AQUACULTURE OF KEMP'S RIDLEY AND LOGGERHEAD SEA TURTLES

The Galveston Laboratory first reared loggerhead hatchlings, provided by the Florida Department of Natural Resources, in Jensen Beach, FL (30), to gain experience before shifting to headstarting Kemp's ridleys (4). After 1977, loggerhead hatchlings reared at the Galveston Laboratory were received from Clearwater Marine Science Center, Clearwater, FL, or Mote Marine Laboratory, Sarasota, FL (31). One clutch of loggerhead eggs was obtained from a nest on Bolivar Peninsula, near Bolivar, TX, and incubated at PINS, and its hatchlings were provided to the Galveston Laboratory.

### Egg Collection and Incubation

Kemp's ridley eggs for the headstart experiment were collected annually from 1978 to 1992 by FWS contractors, Mexican turtle camp personnel, and volunteers. The eggs were exposed to the Rancho Nuevo beach sand or to PINS sand transferred to Rancho Nuevo in polystyrene foam incubation boxes (5,7,8,32), under the working hypothesis that chemical imprinting took place in the egg or hatchling stage (21,33). Eggs to be placed in PINS sand were caught in plastic bags as they were laid, so that they would not come in contact with Rancho Nuevo sand (2,7), and the people who handled the eggs wore sterile gloves. Eggs from a clutch were stacked in an incubation box containing a layer of PINS sand; next, additional sand was packed around and on top of the eggs to prevent them from coming in contact with the box. The eggs were then transported by aircraft, vehicle, or both to PINS for incubation (5,7,8,34). Hatchlings for headstarting also were transported by aircraft from Rancho Nuevo (32) and from the Kemp's ridley breeding experiment at Cayman Turtle Farm, Grand Cayman, British West Indies (10).

The mainstay of the Kemp's ridley recovery program—protection of eggs and hatchlings at the Rancho Nuevo and contiguous nesting sites (2,15,16,35)—is a form of artificial culture. Typically, most of the eggs laid are collected and transplanted into artificial nests within fenced corrals on those beaches, so that they can be monitored during incubation and protected from predators and human exploitation. Hatchlings from the corrals are then protected during their crawl to the water, but must fend for themselves thereafter.

### Sex Determination

Sex in sea turtles is determined by the temperature to which eggs are exposed during incubation. More females are produced at temperatures above the pivotal temperature (i.e., the temperature that produces a ratio of one male to one female), and more males are produced at temperatures below the pivotal temperature (36). As Kemp's ridley eggs were stacked in an incubation box, a temperature sensing probe was placed in the center of the clutch, with a wire leading outside the box for connection to a temperature recorder (5,7). The pivotal temperature for Kemp's ridleys was not known until 1985, and from that year through 1988, the NPS controlled incubation temperatures at PINS so as to produce mostly females (34,36,37). Prior to 1985, mostly males were produced (37,38). The Galveston Laboratory had no control over incubation of loggerhead eggs: All loggerheads reared at the Galveston Laboratory were obtained as hatchlings, with most coming from Florida and one clutch from PINS.

### Imprinting

When the headstart experiment began, chemical imprinting was hypothesized to take place in the egg or hatchling stage (4,33). Kemp's ridley hatchlings that emerged from eggs incubated at PINS or Rancho Nuevo were allowed to crawl to the water before being netted and transferred to the Galveston Laboratory for captive rearing (5). If Kemp's ridleys return to their natal beach as adults, using magnetic navigation (5,21), then the procedures used in their crawl to the water as hatchlings should have sufficed to imprint them to their natal beach. The Padre Island incubation and imprinting phases of the headstart experiment were terminated in 1988, to focus on protecting, documenting, and monitoring Kemp's ridley nests at PINS (34).

### Rearing Facilities and Seawater Management

The building housing the turtle rearing tanks is constructed of steel, and its concrete floor is slightly sloped toward drain troughs covered with fiberglass grates (see Figs. 2–4). Incoming seawater flows through PVC pipes laid in the same troughs that carry waste seawater from the turtle barn (see Figs. 2–4). Each fiberglass rearing tank is equipped with a seawater supply pipe and an elevated standpipe that maintains seawater level (see Fig. 4).

The sea turtles are reared in isolation from each other, to prevent incidents of biting, injury, and infections that arise when they are reared in groups (9,30) (see Figs. 4 and 5). Kemp's ridleys are especially aggressive, even as hatchlings, so isolation rearing increases their chance of survival. As hatchlings, the turtles are isolated in small plastic pots placed in groups of four within a plastic crate (see Fig. 5). After 60 days, the pots are removed, and hatchlings are redistributed, one per crate (see Fig. 5). The crates are bolted together with nylon fasteners into groups of 10 to facilitate handling (see Figs. 5 and 6). Each crate is lined on its four inside walls with high-impact styrene sheeting to prevent both dispersion of food and contact between turtles in adjacent crates. The bottom of each crate is fitted with vinyl-coated wire mesh to allow turtle excrement and uneaten food to sink to the bottom of the rearing tank. The crates are supported by a rack constructed of PVC pipe (see Figs. 3, 5, and 6). When the Kemp's ridleys are 9–11 months old, they are tagged and released into the Gulf of Mexico or adjacent bays (9–11,39,40).

Loggerheads approaching two years of age are required for TED certification. Since they are reared for a longer time than Kemp's ridleys in captivity, they outgrow the plastic crates and must be redistributed into larger vinyl-coated wire-mesh cages within the rearing tanks around one year of age (see Figs. 4–6). The walls of each cage are lined with high-impact styrene sheeting, and the bottom is made of vinyl-coated wire mesh (see Figs. 5 and 6). Cages, in groups of two, are supported by galvanized wire hangers or plastic cable ties attached to wooden poles laid across the rearing tank (see Figs. 4–6).

While isolation rearing is somewhat confining, the turtles exhibit high survival rates and good health. To accustom loggerheads to life in the wild prior to their use in TED certification and eventual release, the turtles are semiwild conditioned outside in seawater ponds or pens for about one month, while being closely monitored so that corrective measures can be initiated if aggressive biting occurs. They are fed squid (thawed after being purchased frozen) during that time and may also eat natural foods that they find within the ponds or pens. Except for Kemp's ridleys used in TED certification in the past, and turtles reared for more than one year in captivity (in some cases, to sexual maturity), captive-reared Kemp's ridleys have not been semiwild conditioned before release into the wild (4,9,10). However, an experimental exercise regimen was shown to improve swimming performance in captive-reared Kemp's ridleys (41).

Seawater is filtered through well points buried in the sand off the beach at Galveston as it is pumped from the Gulf of Mexico (9). It flows into a concrete-lined sump, where particulates are allowed to settle, and then is pumped into insulated fiberglass reservoirs (see Fig. 7). It receives no further filtration or chemical treatment, but is heated during winter with thermostat-controlled, electric immersion heaters placed in some of the reservoirs. Heated and unheated seawater are mixed to the appropriate temperature before being pumped into the rearing tanks, and the temperature is maintained thereafter by controlling the air temperature within the rearing building, using forced-air heaters during winter and exhaust fans during summer (see Fig. 2). The temperature of the seawater in the rearing tanks ranges annually from 23 to 31 °C (73 to 88 °F), with a mean near 27 °C (81 °F), and the salinity ranges 20–39 ppt, with a mean near 31 ppt. Three times per week, rearing tanks are drained to remove uneaten food and turtle wastes and are then refilled with clean seawater. Once per month, each tank is scrubbed with a high-pressure sprayer to remove algae and other materials adhering to the sides and bottom.

Keeping seawater clean and warm is of major importance to successful rearing and disease prevention in sea turtles. Various fungal infections, both external and internal, that eventually lead to death occur if the turtles are reared at temperatures below 20 °C (68 °F) (9,30). Whether this situation results from detrimental effects of cooler temperatures on the immune system, encouragement of growth of fungi by lower temperatures, or other factors is not known. Additional diseases and treatments have been described for Kemp's ridleys and loggerheads reared at the Galveston Laboratory (30,31). Sick or injured turtles are removed from the rearing building and treated in a separate "hospital," which is also used for quarantine, to avoid exposing healthy turtles to diseases.

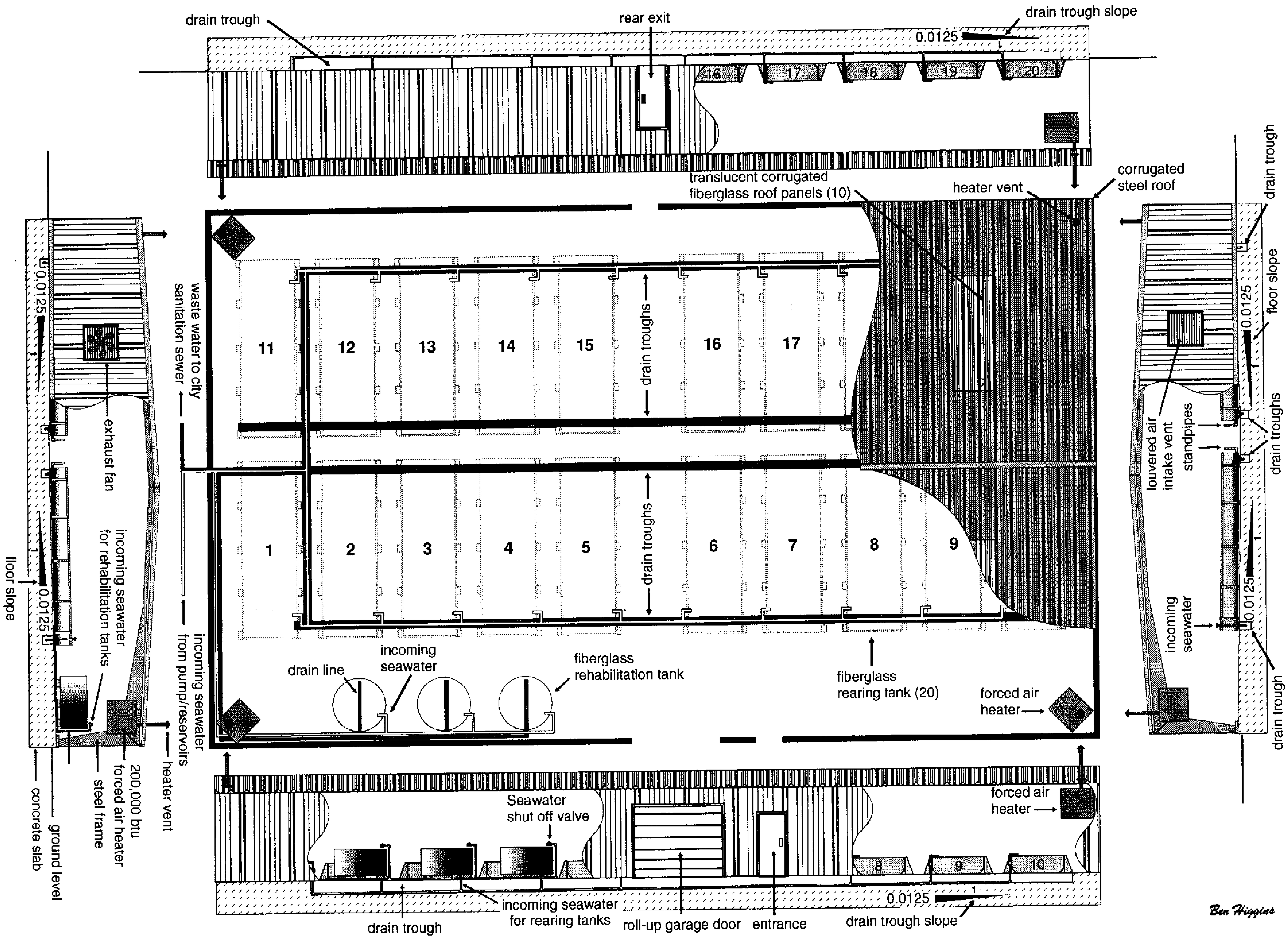


**Figure 2.** Plan and elevations of the sea turtle rearing building, showing rearing tanks and drainage troughs.

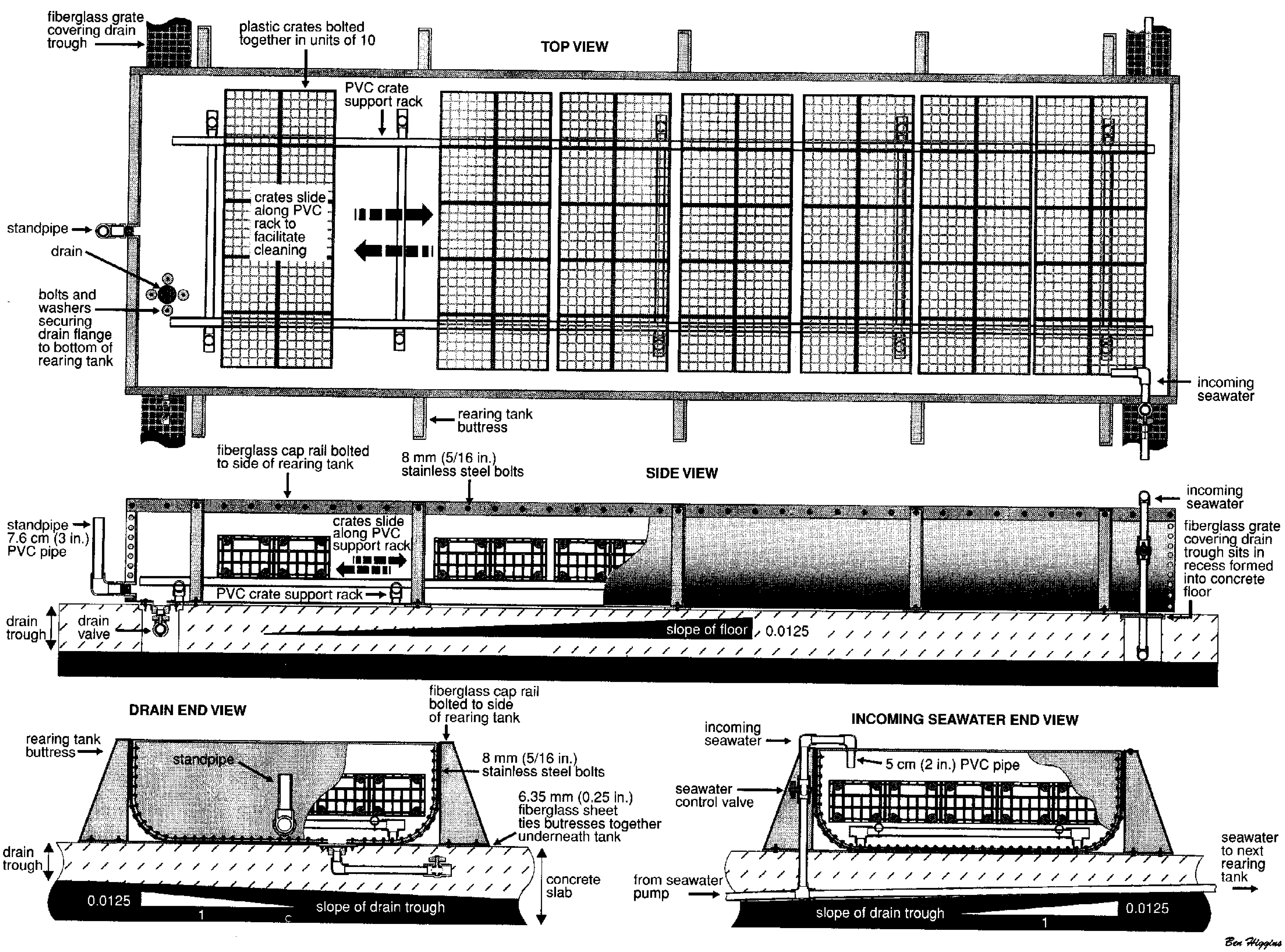


**Figure 3.** Rearing tanks, showing plastic crates and the PVC support rack and plumbing.

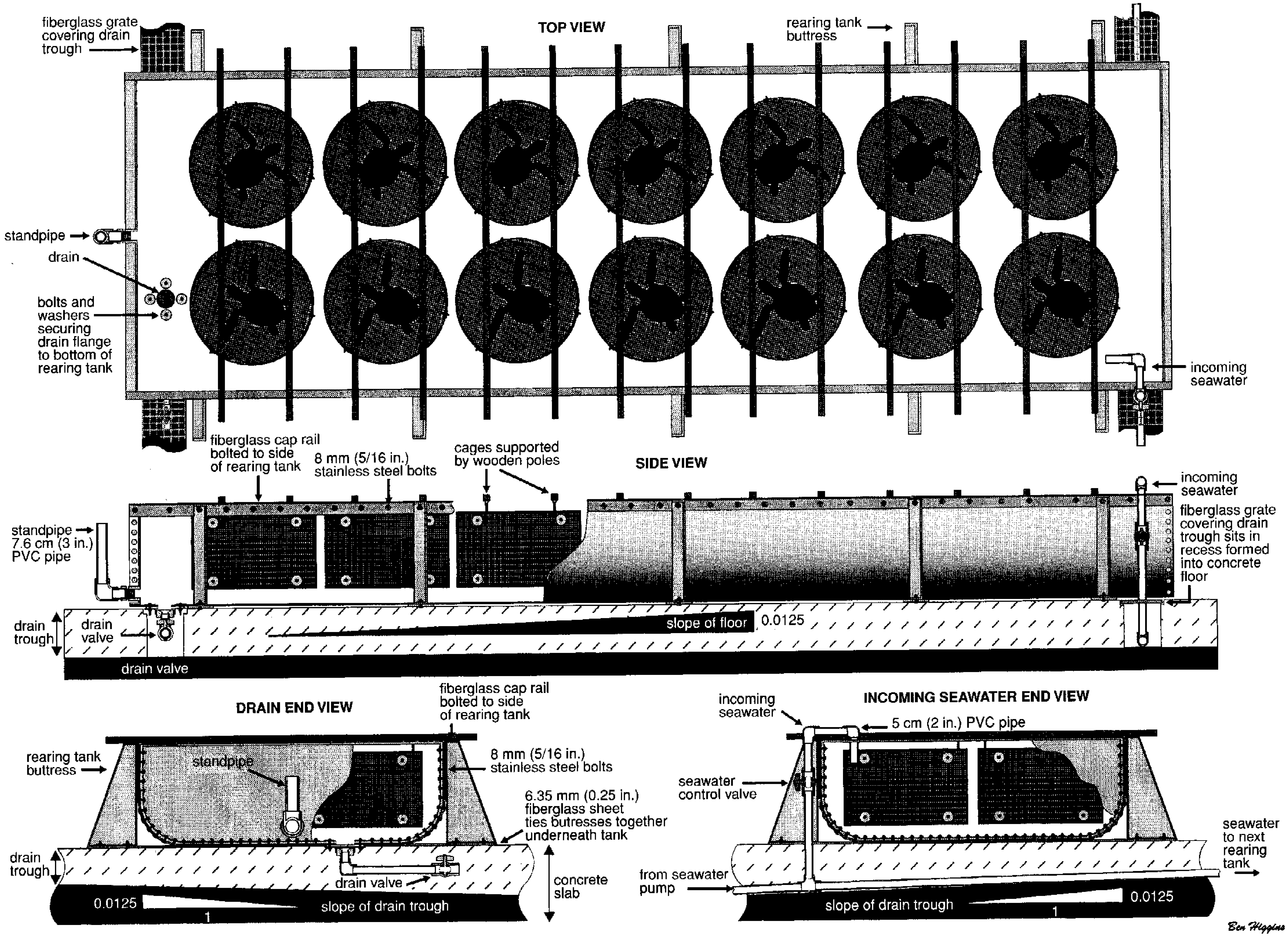


**Figure 4.** Rearing tanks, suspended cages, and the PVC support rack and plumbing.

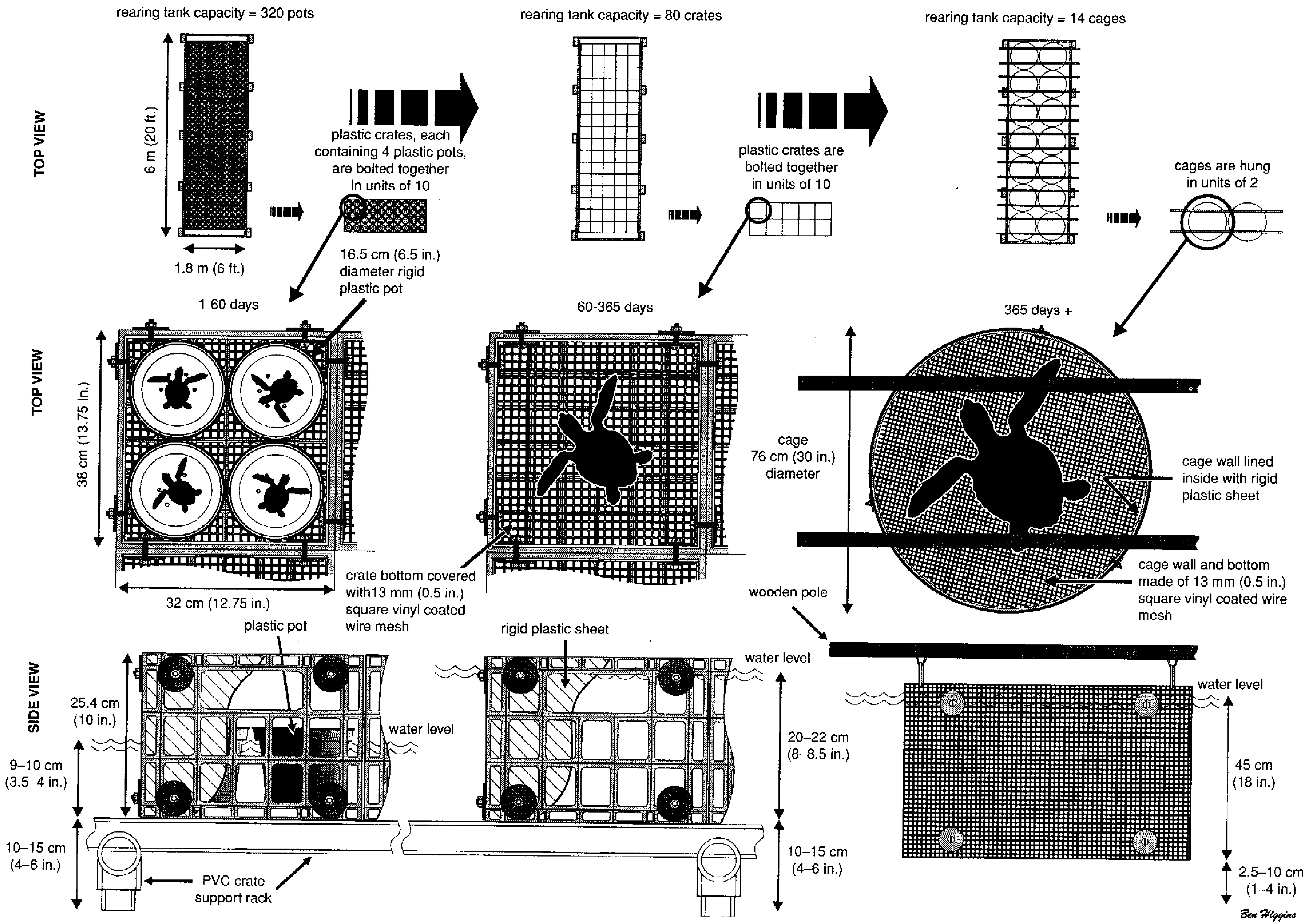


**Figure 5.** Arrangement of plastic pots, crates, and cages within rearing tanks.

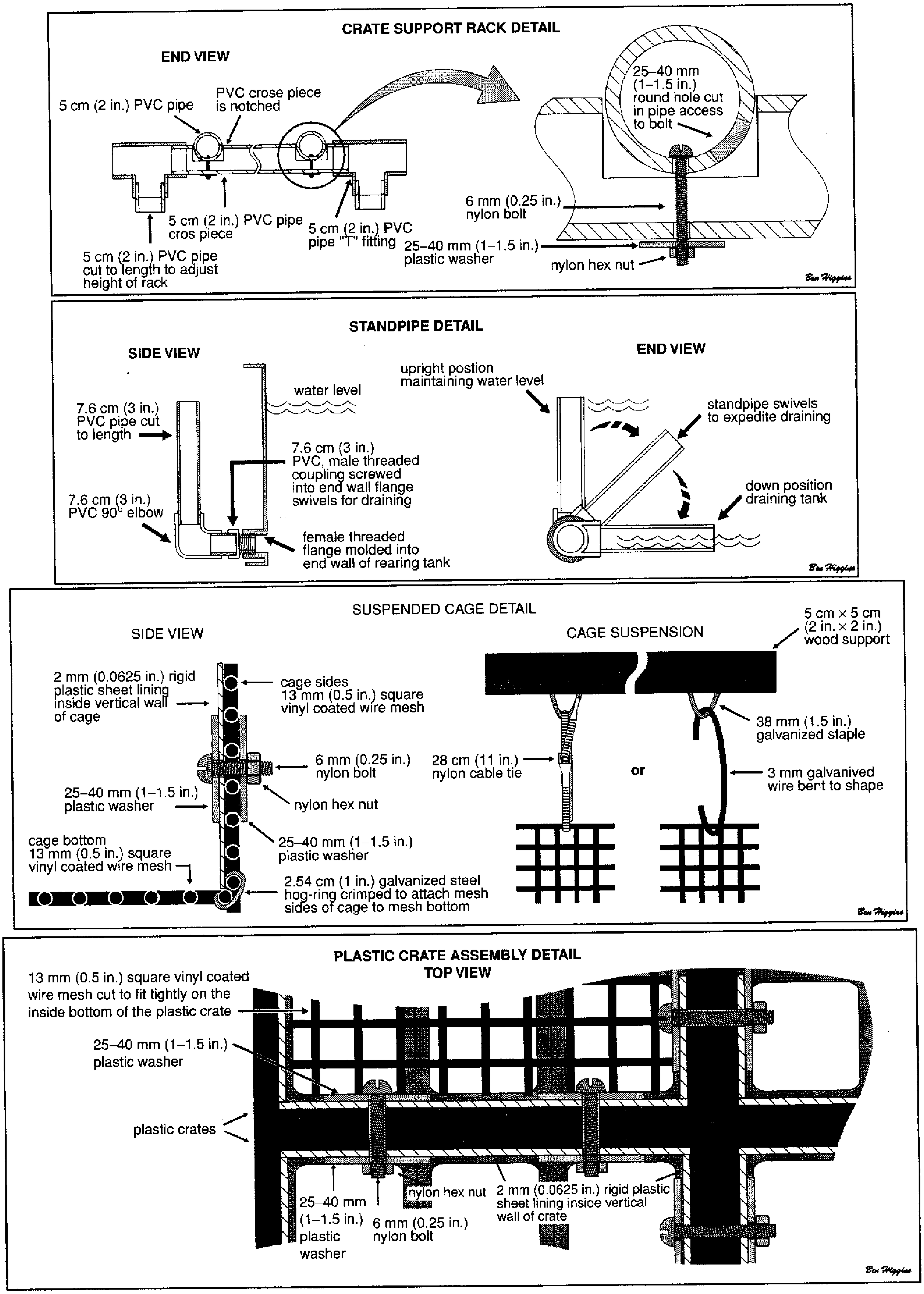


**Figure 6.** Details of the support rack, standpipe-drain plumbing, plastic crate assembly, and a suspended cage.

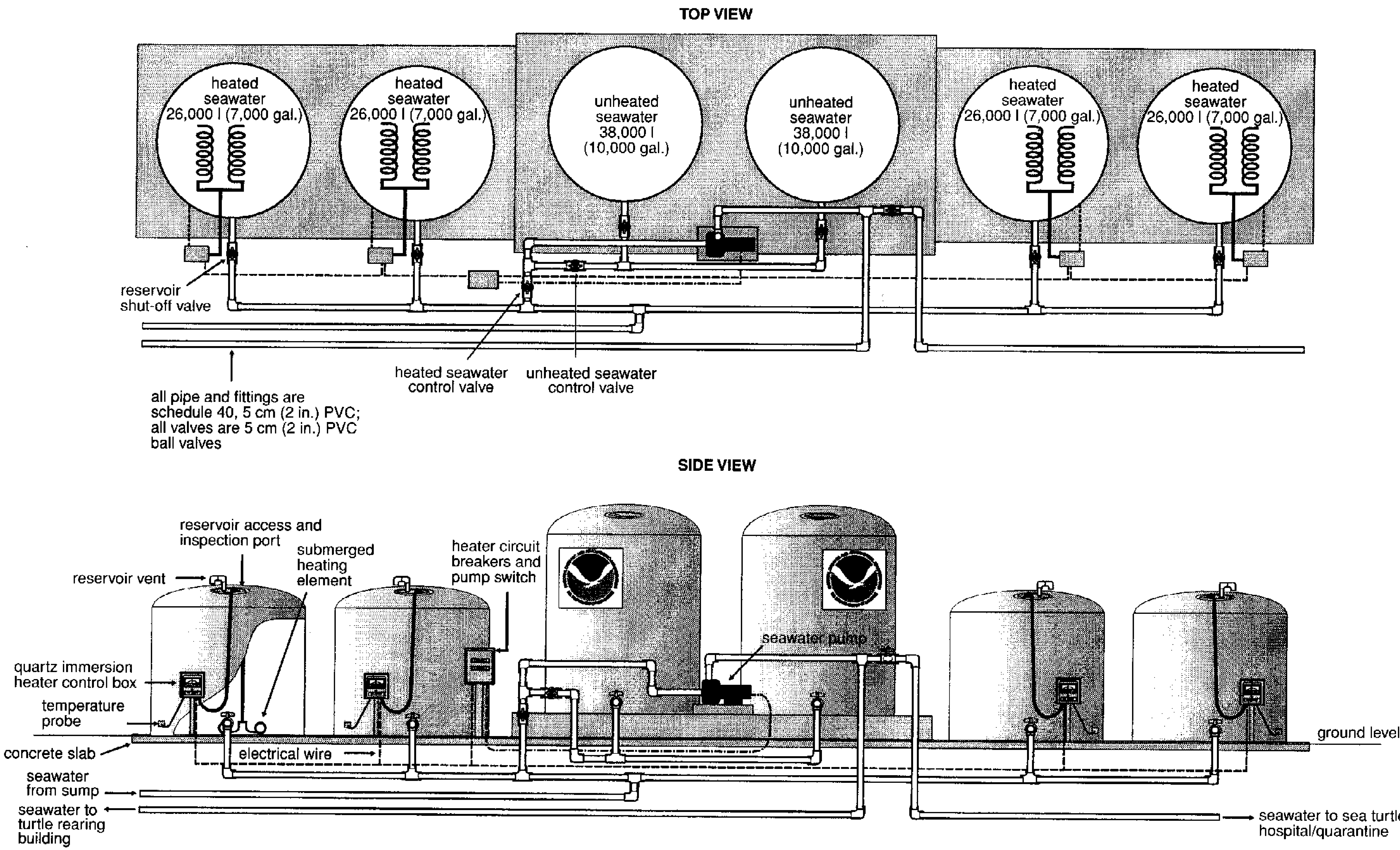


**Figure 7.** Seawater reservoirs, heaters, and PVC plumbing.

### Food, Feeding, Growth, and Survival

The turtles are fed floating feed pellets manufactured by Purina Mills, Inc. (9,42). Each turtle receives a daily ration based on a percentage of the average body weight of a sample of turtles of the same age. Feeding of newly hatched sea turtles is postponed for up to nine days, to allow time for yolk sac absorption (43). The daily ration for hatchlings is about 2% of the average body weight per turtle and is reduced gradually to about 1% by the time that the turtles are one year old. The percentage can be decreased or increased to control growth rate. Sea turtles fed *ad libitum* or oily fish quickly become obese, which eventually leads to fatty degeneration of the liver (44). Each turtle is individually fed a daily ration divided into two equal portions, one fed in the morning and the remainder in the afternoon.

Kemp's ridleys and loggerheads readily eat squid, blue crab, and shrimp, if given the opportunity. They quickly adapt to eating natural foods after long periods of eating pelletized diets (45). However, once they encounter natural foods, they resist eating pellets unless they are extremely hungry.

Under the controlled conditions of captive rearing described herein, Kemp's ridleys can grow to an average weight of 1.26 kg (2.78 lb) and an average straight-carapace length of 19.5 cm (7.7 in.) in a year (11). The first-year survival rate in captivity for the 1978–1992 year-classes combined was 87% (11), and in recent years it has exceeded 95%. Under similar conditions, loggerhead growth and survival during the first year in captivity are comparable to that of Kemp's ridleys (Clark Fontaine, personal communication, February 1998).

### Captive Breeding

Responding to recommendations by prominent sea turtle scientists (46,47), the government of Mexico and the Galveston Laboratory distributed Kemp's ridleys to cooperating marine aquaria (see Table 1) in the late 1970s to mid-1980s, to be reared to maturity and held as a breeding stock in case other conservation efforts failed (2,3,15,28,48). The turtles were dispersed among numerous marine aquaria, in order to distribute the costs of their maintenance and to avoid catastrophic losses due to disease outbreak or other causes of mortality (47). Cayman Turtle Farm, which received most of the turtles, was the first to breed Kemp's ridleys successfully, producing viable hatchlings from seven-year-old captive reared animals in 1986 (49). Under an agreement with the government of Mexico, Cayman Turtle Farm still maintains about 400 Kemp's ridleys. Included are survivors from the original stock received from Mexico, as well as offspring produced by captive breeding survivors from the stocks received from both Mexico and the United States (Rene Márquez–Milan, personal communication, November 1997). The Kemp's ridleys at Cayman Turtle Farm provided opportunities for studying reproductive behavior and physiology (28,50–52). Other marine aquaria also gained valuable experience with captive rearing (see Table 1). The experimental captive breeding program in the United States was terminated in 1988, and most of the surviving turtles in the dispersed brood stock have since been released into the wild. For example, survivors in the group of turtles originally obtained as yearlings by Cayman Turtle Farm from the United States were returned as adults by FWS to the Galveston Laboratory and released into Galveston Bay, TX, in 1992.

**Table 1. Marine Aquaria that Received Kemp's Ridleys from the Galveston Laboratory for Purposes of Developing a Captive Brood Stock**

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|---|
| Audubon Park Zoo, New Orleans, LA |
| Bass Pro Shops, Springfield, MO |
| Cayman Turtle Farm, Grand Cayman, British West Indies |
| Clearwater Marine Science Center, Clearwater, FL |
| Dallas Aquarium, Dallas, TX |
| Gulfarium, Fort Walton Beach, FL |
| Key West Aquarium, Key West, FL |
| Marine Life Park, Inc., Gulfport, MS |
| Marineland of Florida, Inc., St. Augustine, FL |
| Miami Seaquarium, Miami, FL |
| New England Aquarium, Boston, MA |
| North Carolina Marine Resources Center, Kure Beach, NC |
| University of Texas–Pan American, Coastal Studies Laboratory, South Padre Island, TX |
| San Antonio Zoological Gardens and Aquarium, San Antonio, TX |
| Sea-Arama Marineworld, Galveston, TX |
| Sea Turtles, Inc., South Padre Island, TX |
| Sea World of Florida, Orlando, FL |
| Sea World of Texas, San Antonio, TX |
| Theater of the Sea, Islamorado, FL |
| Turtle Kraals, Key West, FL |

## EPILOGUE

The Galveston Laboratory has reared, tagged, and released more than 23,000 Kemp's ridleys (40) and hundreds of loggerheads since 1978. Six nestings of headstarted Kemp's ridleys were documented from 1996 through 1998 at the Padre Island National Seashore, the beach to which they had been imprinted as hatchlings (53,54). Despite the Galveston Laboratory's successes in experimental captive rearing and reintroduction of Kemp's ridleys and loggerheads into the wild, the usefulness of such an approach in the conservation and management of sea turtle stocks remains in doubt (55). A listing of Galveston Laboratory reports and publications on sea turtle research (56) can be obtained by contacting the laboratory at 4700 Avenue U, Galveston, TX 77551 USA (Phone 409-766-3500, Fax 409-766-3508), or the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161 USA (Accession No. PB97-167415, Paper copy US$19.50 Microfiche US$10.00). A recent assessment of the status of Kemp's ridley and loggerhead stocks (57) can be obtained by contacting the NMFS Miami Laboratory, Sea Turtle Program, 75 Virginia Beach Drive, Miami, FL 33149 USA, or by contacting NTIS.

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See also SEA TURTLE CULTURE: GENERAL CONSIDERATIONS.

## SHRIMP CULTURE

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### OUTLINE